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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

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☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

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OR *Type Customer Number here*

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 11 ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 3 ☒ Other (specify) 3 Sheets Photos

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☒ Applicant claims small entity status. See 37 CFR 1.27.
☒ A check or money order is enclosed to cover the filing fees
☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number 02-4345
☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($) $80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☐ No.
☐ Yes, the name of the U.S. Government agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE

Date 10-06-03

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

IGNITION SYSTEMS

The present invention relates to ignition systems, particularly catalytic ignition systems. More particularly, the present invention relates to such an ignition system that can be used in remote environments to ignite a combustible mixture, e.g. a hydrocarbon/oxygen gas containing mixture.

Ignition systems for igniting a combustible mixture at a remote location are used in a variety of applications. By way of example, such ignition systems can be used to ignite combustible mixtures in flare stacks in refineries and chemical plants. A prime example of the use of an ignition system is their use in igniting burners disposed in earth boreholes drilled into a subterranean formation. Generally, the subterranean formation is one that contains a hydrocarbonaceous material e.g.: coal, shale, tar sands, oil, etc. For example, it has been proposed to drill one or more boreholes into a coal formation and then, by the generation of heat in the borehole, gasify the coal in the formation to result in the in situ generation of synthesis gas. United States Patent Application Publication U.S. 2003/0173081 (`081 Publication) describes methods and systems for the production of hydrocarbons, hydrogen and/or other products from various oil containing formations. In the `081 Publication (incorporated herein by reference), there is described the in situ conversion of hydrocarbons to produce more valuable hydrocarbons, hydrogen and/or novel product streams from underground oil containing formations. In the process proposed in the `081 Publication, one or more heat sources is installed into a hydrocarbon (oil) containing formation to heat the formation, one of the goals being to raise the temperature in the formation above the pyrolyzation temperature of the hydrocarbons in the formation. The `081 Publication describes numerous embodiments and systems for supplying heat, preferably at pyrolysis temperatures, to the oil containing formation to heat and/or

pyrolyze the oil and convert at least a portion of the oil to more valuable and more easily recoverable hydrocarbons, the produced more valuable hydrocarbons being recovered from the downhole formation.

While a number of electrical heating elements have been proposed to heat downhole formations, they all suffer from the inherent problems of requiring hard wiring to the surface as well as being expensive and lacking efficiency. To overcome some of these difficulties, it has been proposed to combust a fuel, the combustion gases being used as the heat source. In this regard, it has been proposed that the combustion may take place in the formation in a well, and/or near or at the surface. For example, the combustion in the formation may be in the form of a fire-flood. An oxidizer may be pumped into the formation. The oxidizer may be ignited to advance a fire front towards the production well.

Flameless combustors may be used to combust the fuel within the well. Flameless combustors are demonstrated, for example, in U.S. Patent Nos. 5,255,742, 5,404,952, 5,862,858, and 5,899,269. These flameless combustors operate by preheating a fuel and combusting it to a temperature above an auto-ignition temperature of the mixture. The fuel and combustion air are then mixed in the heating zone to combust. In the heating zone, the flameless combustor, and a catalyst surface may be provided to lower the auto-ignition temperature of the fuel and air mixture.

It clearly would be desirable to have an ignition source or system which could be positioned in the wellbore, e.g. in a tubing having an ID as small as a 3" positioned in the wellbore, and which, without the use of electrical igniter or heaters, and without any preheating of a fuel and oxygen

containing mixture, could ignite a fuel/oxygen gas containing mixture, the combustion gases from the fuel being used to heat an airstream being pumped into the tubing, the combined heated air and combustion gases then being used to heat the formation to the desired temperature e.g. the pyrolysis temperature of at least a portion of the oil in the formation.

In one aspect, the present invention provides an ignition system which can be positioned in a relatively small diameter tubing e.g. 3" I.D. and which will ignite a combustible fuel e.g. a mixture of a hydrocarbon and an oxygen containing gas, without the use of electrical heaters, preheating of gases, etc.

In an especially preferred embodiment, the system of the present invention employs a composition of matter which, when exposed to a first gas/oxygen containing gas (oxidizer) mixture, results in an exothermic reaction causing the temperature of the composition of the matter to be elevated above the auto-ignition temperature of the first gas with consequent ignition of the fuel gas/oxidizer mixture to produce a pilot flame. The resulting pilot flame can be propagated into a burner ignition zone to ignite a fuel mixture supplied to suitable burner(s).

In another preferred embodiment of the present invention, there can be employed a series of ignition systems as described above in conjunction with a series of burners which can be spaced axially along the inside of the burner tubing so as to provide a multiplicity of heat generating sources along the length of the tubing. The hot combustion gases flowing towards the bottom of the tubing disposed in the wellbore can then exit the bottom of the tubing and flow up the annulus between the burner tubing and a second concentrically disposed tubular surrounding the burner tubing.

Alternatively, the hot combustion gases can flow into the annulus between the burner tubing and the formation in the case of an open hole, uncased borehole. Additionally, air from the surface can be pumped down through the burner tubing, the air being heated by the combustion gases and/or the flame from the burners.

In yet another preferred aspect of the present invention there is provided an igniter/burner assembly wherein an igniter system, as described above, is mounted, on/in or in sufficiently close proximity to a burner that is supplied with a combustible fuel. The burner may take the form of one or more nozzles, jets or openings in a burner block or housing, each of the nozzles being supplied with a combustible fuel mixture, the igniter system being positioned sufficiently close to at least one nozzle so that it will ignite a combustible fuel mixture issuing from the nozzle and subsequently all other nozzles.

Basically, the present invention is a self-igniting system which defines a chamber or support assembly, a source of a first gas and an oxygen containing gas (oxidizer) to the chamber or the support assembly, and a composition of matter disposed in the chamber or supported on the support assembly that causes auto ignition of the first gas and oxidizer mixture to produce a flame or at least increase the temperature of the composition of matter to a point which will result in ignition of a combustible mixture e.g. a hydrocarbon such as methane, the system being positioned in tubing or other such earth bore tubulars, e.g., tubing, casing, etc. to ignite a combustible fuel mixture in the tubular as, for example, igniting a suitable burner disposed in the tubular, the burner being supplied with a combustible fuel mixture.

The oxidizer is an oxidizing gas of the type that will support combustion. Typically, the oxidizer will be an oxygen containing gas, e.g., air, O_2, etc. The interaction or reaction between the first gas and the composition of matter produces an exothermic reaction, which raises the temperature of the composition of matter to above the auto-ignition temperature of the second gas. At the present time, the invention contemplates that the first gas is hydrogen, the oxidizer is air and the composition of matter is platinum in any form which when contacted with the hydrogen/oxidizer mixture results in the catalyzed reaction of hydrogen and the oxygen in the air. Typically, when the hydrogen/air mixture contacts the platinum, the temperature of the platinum is elevated well above the auto-ignition temperature of hydrogen that is about 1,080°F. The hydrogen/air mixture ignites and results in a flame that can be referred to as a pilot flame that can be propagated to a burner ignition zone to ignite a combustible mixture issuing from a suitable burner assembly into the burner igniter zone.

It is well known that the combination of hydrogen and oxygen to form water is an exothermic process; however, hydrogen and oxygen will not react automatically when mixed together because of the large activation energy needed to initiate the reaction. It is also known that the mechanism of the reaction is extremely complex and that one of the initiation steps is breaking of the bond between the two hydrogen atoms of the hydrogen molecule which requires 432kJ/mole. This energy is typically initially provided by a spark or flame. After the reaction begins, the energy produced from it will provide the necessary energy to continue breaking apart the hydrogen molecules. A catalyst provides an alternative mechanism that has a lower activation energy that allows the reaction to proceed without the requirement of the initial addition of energy via a flame or spark. Hydrogen

molecules will adsorb to the platinum surface. The energy of the interaction between the hydrogen atoms and the platinum surface contributes to the breaking of the bond between the hydrogen atoms in the hydrogen molecule. The separate hydrogen atoms are then free to react at the surface or leave the surface and participate in the water forming steps.

While the invention will be described with particular reference to the use of hydrogen and an oxidizer (air) impinging on platinum, it is to be understood that it is not so limited. Thus, the invention contemplates the use of other compositions of matter e.g. palladium, which will react with hydrogen in a fashion similar to that described above with respect to the reaction between hydrogen and platinum. Additionally, any other metal, alloy, or composition of matter which will react with hydrogen in the presence of an oxidizer (air) to bring about the catalyzed reaction of hydrogen and oxygen described above is also contemplated. Further, although currently unknown to the inventor at this time, the invention also contemplates that other gases or mixtures thereof can be brought into contact with other compositions of matter, also presently unknown to the inventor, which will result in a catalyzed auto-ignition of such other gases in the presence of a suitable oxidizer such as air, oxygen or the like.

Referring to Figure 1, there is shown an embodiment of the igniter system of the present invention in combination with a burner nozzle (burner). In Figure 1, the igniter system/burner is shown as being disposed in a 3" ID pipe. In the embodiment shown in Figure 1, hydrogen, at a predetermined pressure, is brought through a conduit and introduced into an inspirator via a bypass. As explained in Figure 1, once the hydrogen exits the inspirator orifice, it is mixed with air and directed to the pilot nozzle where it contacts the platinum catalyst disposed in a chamber. Upon

contact of the hydrogen gas with the platinum catalyst, an exothermic reaction ensues with the resulting production of water and a larger release of heat. The temperature rise of the catalyst will increase until ignition of the hydrogen/air mixture occurs. Once ignition occurs, and a pilot flame is lit, the flow of hydrogen is discontinued and methane is now passed through the conduit where it now passes through the bypass into the inspirator and subsequently through the burner ports of the burner nozzle. The pilot flame issuing from the pilot nozzle will ignite the methane passing out of the burner ports that will continuously burn so long as the methane/air supply is not discontinued.

Figure 2 shows another embodiment of the present invention. In the embodiment shown in Figure 2, hydrogen is supplied via a line where it is mixed in a mixing chamber with air from an air pipe (not shown), the hydrogen/air mixture being supplied to the platinum catalyst in a chamber wherein the platinum catalyst is disposed. In the embodiment shown in Figure 2, the hydrogen and air are supplied at a suggested predetermined pressure. As seen, the pilot nozzle that opens into the chamber in which the platinum catalyst is supported is surrounded by an array of burner ports. As the hydrogen and platinum react, an exothermic reaction ensues resulting in the production of water and a larger release of heat which rapidly raises the temperature of the catalyst (platinum) until ignition of the gas mixture occurs. Once the hydrogen/air mixture is ignited, the methane supply is turned on resulting in it being ignited to form a pilot flame issuing through the pilot nozzle. Once the pilot flame is ignited, the hydrogen and air supplies can be turned off, and the methane flow continued to the burner through the burner ports which will be ignited by the pilot flame issuing from the pilot nozzle and, so long as the methane/air supply is continued, the burner will stay lit.

Figure 3 shows another embodiment of the present invention wherein the system is disposed

in a 5" ID pipe. As discussed on Figure 3, the four pipe igniter/burner system is designed to fit inside a 5" casing eliminating the need for the 3" air pipe used in the designs shown in Figures 1 and 2. It differs from the designs shown in Figures 1 and 2 in that 100% of the combustion air required is supplied to each individual burner by 1" air pipes. Using this technique, each burner is supplied with clean combustion and to ensure a maximum BTU output and performance of all the burners as well as applying direct flame to the 5" casing wall. It should be noted that in this system, the burners are installed such that the flame issuing from the burner ports would be facing up the borehole, i.e., towards the surface.

All of the systems described in Figures 1-3 can be used in earth boreholes and more particularly in either cased or uncased earth boreholes. Furthermore, it will be appreciated that a series of the systems shown in Figure 1-3 can be axially positioned along the length of the tubular/borehole at any desired distance.

While in Figures 1-3 reference is made to a platinum catalyst, it would be understood that the platinum can be supported in a variety of matrices, e.g., in an alumina matrix or in some other ceramic type matrix that can withstand high temperatures. Furthermore, it will be apparent that there are other ways to support the platinum, in whatever form desired, in the igniter chamber/support.

A prototype igniter/burner assembly having an ignition system basically as described above was designed, built and tested for use in a 100,000BTU/hr burner assembly.

The assembled igniter/burner assembly is shown in Photo A, while the face of the burner nozzle with the burner ports and the center pilot nozzle is shown in Photo B.

In Photo C, the burner assembly is shown in its ignited condition. As the text on the page of Photo C states, the combustion air was fed at an estimated rate of 150scf/min for the test period. As can be further gleaned from the text flame retention on the nozzle was acceptable at all flow rates up to and beyond 100,000BTU/hr.

With reference to Photo D, it can be seen that in the prototype the catalyst was retained in a stainless steel hexagon shaped chamber, hydrogen and air being introduced via tubes into the end of the chamber allowing the gases to flow over the catalyst. A control panel having an arrangement of timing devices (See Photo D) allowed the flow of hydrogen and air for 15 seconds every 60 seconds, which completed one cycle. Each cycle triggered an electronic counter to verify the number of cycles. Flame produced by the catalytic ignition system during the cycles was proven by a thermocouple and monitored by an event recorder. Although some misfires occurred due to the inability of the air compressor to maintain a constant flow of air to the catalytic ignition system, as seen on the counter and Photo E, 2,096 cycles were recorded before the test was concluded.

The ignition system of the present invention provides a virtually foolproof method to ignite a combustible gas or other combustible mixture in a remote environment such as in an earth borehole or in a tubular member disposed in an earth borehole. No electric connections are required. Indeed, with the present system, and in a preferred embodiment, the only requirements are platinum in a suitable form disposed in the chamber or held in a support, a supply of hydrogen and an oxidizer to

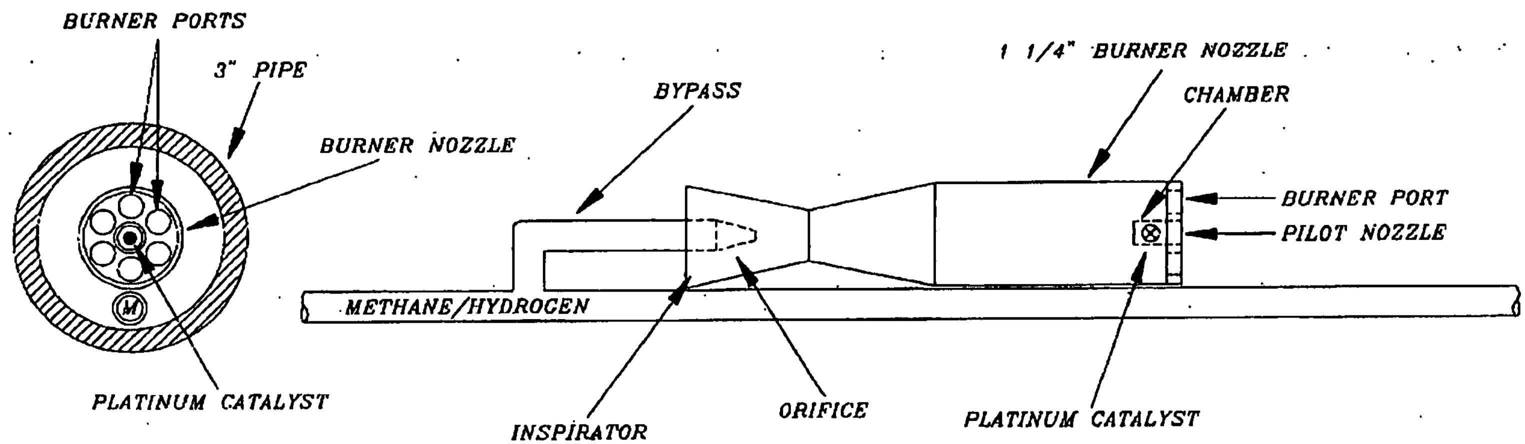
the platinum and a combustible fuel to generate heat once the hydrogen/air mixture has ignited, which in turn will ignite the combustible fuel. The system is ideal for downhole ignition because only tubing is required to convey the gases required. As is well known to those skilled in the art, such tubing can be of high quality alloys that are corrosion resistant, withstand extremely high temperatures and are extremely durable.

It is anticipated that the unique ignition system of the present invention can be designed for multiple burners, e.g., 15 to 40, which can be spaced along the length of tubing disposed at a borehole. It is also anticipated that the burner output from each burner will be 50,000 to 125,000 BTU/hr. The igniter system of the present invention will be capable of handling inlet combustion temperatures from ambient to 500° F while withstanding downstream combustion air temperatures of up to 1,500° F. The igniter system of the present invention can be used in hot start-up conditions, as well as under conditions where water is present, i.e., wet conditions. As described above and as clearly shown in the drawings and photos, the ignition system, including burners, will fit inside a 3" I.D. burner tube. It is anticipated that the service life of the igniters will be 3-5 years with little to no maintenance.

The marked novelty of the igniter system of the present invention is best demonstrated by the fact that under the parameters set out above, e.g., having to dispose the burners in a 3" I.D. tube, in downhole conditions at elevated temperatures, in the presence of moisture and with a repetitive and long lifetime, it accomplishes what electric igniters or any other heretofore known ignition systems cannot accomplish. It overcomes the difficulty of having to protect ignition wires in a hard wired system using an electric igniter from prolonged exposure to a temperature of 1,500° F, a temperature

that would almost certainly damage such electrical systems over time. It permits the use of multiple burner systems, e.g., 15 to 40 burner systems, each with an igniter, and such a system would be virtually impossible using electrical igniters because the small I.D. of at least some of the burner tubes in which the igniter system will be placed would not permit the use of 15 to 40 ignition wires that would be required in such a multiple burner system. Furthermore, in any electric/spark ignition system it is almost certain that delicate ceramics or the like would be used and such materials are frangible, easily damaged and would require excessive maintenance. Additionally, in an extended length of burner tubing, e.g., 5,000 ft., the voltage drop to the igniters would be excessive requiring repeaters, again complicating the system and making it virtually impossible to fit it into a small diameter (3" I.D.).

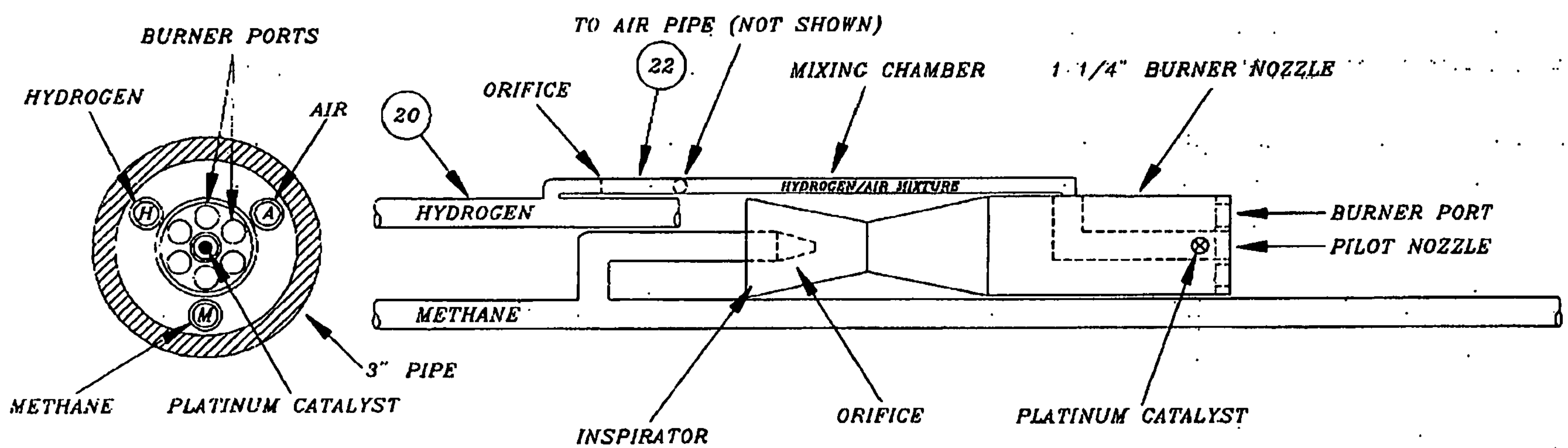
FIGURE 1



CATALYTIC PILOT IGNITION (1 PIPE) - SEQUENCE OF EVENTS

THE HYDROGEN GAS SUPPLY IS TURNED ON AND ADJUSTED TO A PREDETERMINED PRESSURE, ALLOWING THE FLOW OF GAS TO THE INSPIRATOR. ONCE THE HYDROGEN EXITS THE INSPIRATOR ORIFICE, IT IS MIXED WITH AIR AND DIRECTED TO THE PILOT NOZZLE WHERE IT COMES IN CONTACT WITH THE PLATINUM CATALYST. WHEN THE GAS COMES IN CONTACT WITH THIS CATALYST, A CHEMICAL REACTION OCCURS. THE END RESULT IS THE PRODUCTION OF WATER AND A LARGE RELEASE OF HEAT. THIS RELEASE OF HEAT WILL RAPIDLY RAISE THE TEMPERATURE OF THE CATALYST UNTIL IGNITION OF THE GAS MIXTURE OCCURS. ONCE IGNITION OCCURS, THE METHANE GAS SUPPLY IS TURNED ON AND THE HYDROGEN GAS SUPPLY IS TURNED OFF SIMULTANEOUSLY.

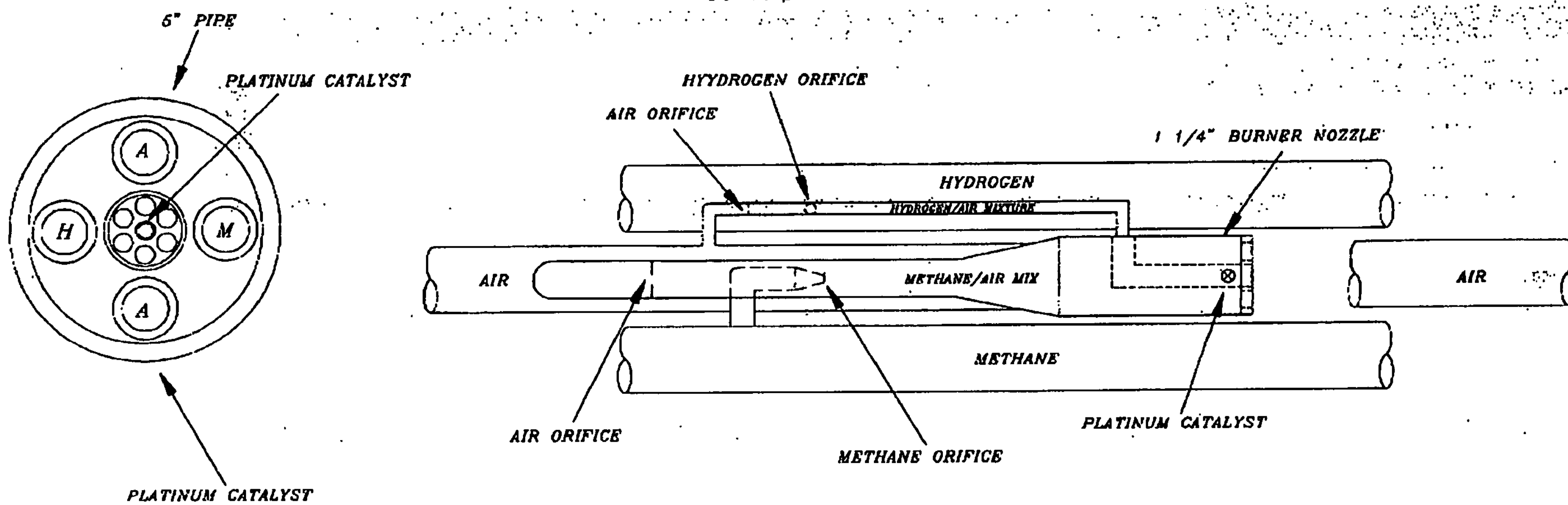
FIGURE 2



CATALYTIC PILOT IGNITION (3 PIPE) - SEQUENCE OF EVENTS

THE HYDROGEN GAS AND AIR SUPPLIES ARE TURNED ON AND ADJUSTED TO A PREDETERMINED PRESSURE. THE GASES FLOW THROUGH THEIR RESPECTIVE PIPES AND ORIFICES TO THE HYDROGEN/AIR MIXING CHAMBER ON THE PILOT. AFTER MIXING IN THIS CHAMBER, THE FLOW OF THE MIXED GAS IS DIRECTED OVER THE PLATINUM CATALYST. WHEN THE GAS COMES IN CONTACT WITH THIS CATALYST, A CHEMICAL REACTION OCCURS. THE END RESULT IS THE PRODUCTION OF WATER AND A LARGE RELEASE OF HEAT. THIS RELEASE OF HEAT WILL RAPIDLY RAISE THE TEMPERATURE OF THE CATALYST UNTIL IGNITION OF THE GAS MIXTURE OCCURS. ONCE THE MIXTURE IS IGNITED, THE METHANE SUPPLY FEEDING GAS TO THE PILOT IS TURNED ON AND PILOT IGNITION WILL OCCUR. AFTER THE PILOT IS IGNITED, THE HYDROGEN AND AIR SUPPLIES CAN BE TURNED OFF.

FIGURE 3



4 PIPE BURNER SYSTEM WITH CATALYTIC IGNITION

THIS 4 PIPE BURNER SYSTEM IS DESIGNED TO FIT INSIDE A 5" CASING, ELIMINATING THE NEED FOR THE 3" "AIR PIPE" USED IN PREVIOUS DESIGNS. IT DIFFERS FROM THE OTHER SYSTEMS IN THAT 100% OF THE COMBUSTION AIR REQUIRED IS SUPPLIED TO EACH INDIVIDUAL BURNER BY THE 1" AIR PIPES. THIS IS DONE TO PROVIDE EACH BURNER WITH CLEAN COMBUSTION AIR ENSURING MAXIMUM BTU OUTPUT AND PERFORMANCE OF ALL THE BURNERS DOWNHOLE AS WELL AS APPLYING DIRECT FLAME TO THE 5" CASING. NOTE THAT IN THIS BURNER SYSTEM, THE BURNERS ARE INSTALLED FACING THE DIRECTION OF INSTALLATION.

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